hips2fits, fast generation of FITS cutouts from HiPS surveys

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Abstract

We have developed hips2fits, a new service generating FITS images cutouts from Hierarchical Progressive Surveys (HiPS), computing bilinear interpolation from HiPS tiles for any user-provided WCS projection.
The code base is powered by Astropy and Rust (wrapped in cdshealpix-python library) and uses Numba to speed up the process. The generation time scales linearly with the number of pixels of the requested cutout and reaches 1 million pixel per second.
The service takes advantage of the huge collection of more than 500 image HiPS available at CDS and at other HiPS nodes.
The Web API is exposed by the Falcon framework.

Test it!

- The service is up and running. Documentation is available at

  http://alasky.u-strasbg.fr/hips-image-services/hips2fits

Service API

`hips2fits?hips=…&` | `ra=&dec=&fov=&proj=…` **`&width= &height=`** `&format=fits`
`wcs=…`

any of the **500+ available image HiPS** (full list: http://aladin.u-strasbg.fr/hips/list)

projection can be specified:
- as a key-value **WCS dictionary**
- as a set of center **position**, **size** on the sky, **projection name** parameters

image dimension (width x height) is **limited** to **30 million** pixels

In addition to **FITS**, users can ask for **JPEG** or **PNG** outputs.
In this case, they can set the min/max cuts, the stretch and the color map.

1 - Initial tests and developments

- Ability to retrieve a FITS cutout from a HiPS has been available in Aladin Desktop for a few years. Our first efforts exposed this code behind a Tomcat servlet.
- In parallel, as HiPS tiles come with a proper WCS (CTYPE RA/DEC--HPX), we have tested several mosaicing/ reprojection engines as *Montage*, *reproject* and *SWarp*.

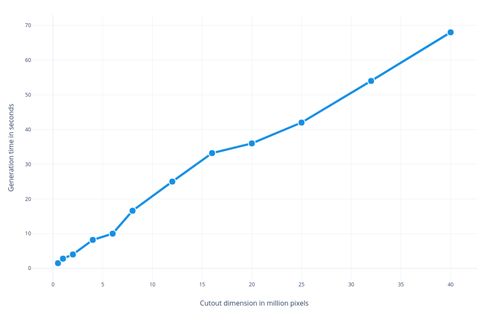
  → Eventually, we decided to develop our own Python-based code for three main reasons: exhaustive support of WCS projections provided by Astropy, performances, full-control of the processing pipeline.

2 - Algorithm

1. For each (x, y) pixel: compute α, δ using **Astropy** WCS
2. Retrieve tiles covered by the cutout
   —> quite fast as most HiPS are available or mirrored at CDS
3. For each (α, δ): retrieve respective contribution from 4 nearest HEALPix cells, using **cdshealpix** (Rust-based) Python library
4. Actual bilinear interpolation computation, accelerated by **Numba**

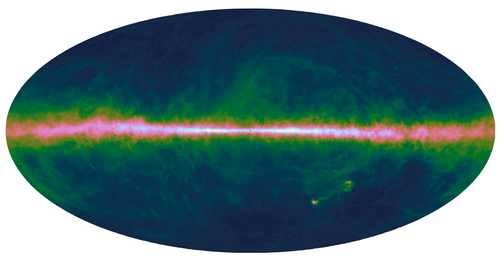
3 - Performances

Our benchmarks show that time for cutout generation grows linearly with image dimension.
Average rate is 500k pixels per second.
Half of this time is dedicated to read the FITS tiles.

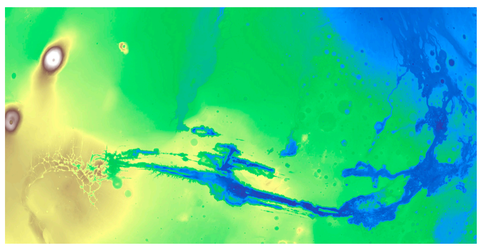


4 - Examples of generated cutouts

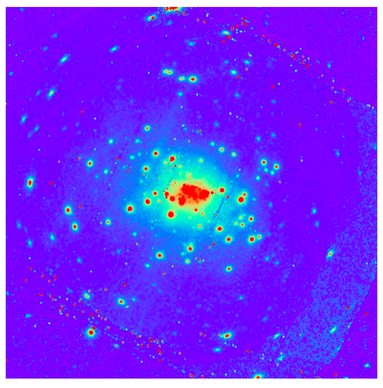
The service is quite versatile, able to produce quickly cutouts at any resolution, from all-sky surveys, pointed observations or planetary data. Here are cutout outputs generated by the service:



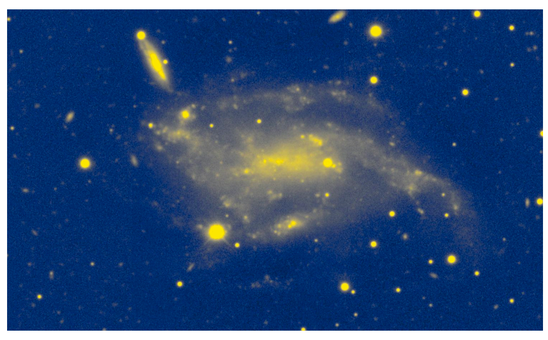
All-sky Mollweide view of HI4PI



MARS MOLA cutout centered on Valles Marineris



XMM cutout of Andromeda galaxy



DECaLS g-band view of UGC 10041

Future plans

- Access from *astroquery.cds* module
- Extension to cube cutouts from HiPS cubes
- Achieve convergence with IVOA SODA interface

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